December 10th, 2024
Tennessee Valley Authority
400 West Summit Hill Drive,
Knoxville, TN 37902

Subject: Comments on Draft 2025 IRP

Dear TVA,

The Nuclear Innovation Alliance (NIA) is a non-profit "think-and-do" tank working to enable advanced nuclear energy as a climate and energy security solution. Through policy analysis, research, outreach, and education, NIA is catalyzing the next era of nuclear energy. We focus on both federal and state policy reform to support advanced reactor development and deployment while meeting national environmental and energy security goals.

NIA commends TVA for undertaking a thorough planning process, for involving external stakeholders, and inviting meaningful public input. The Draft 2025 TVA IRP is a thoughtful and useful analysis of TVA's options for selecting economic resources to meet uncertain future market and regulatory conditions. In this comment we raise some concerns about the treatment of advanced nuclear energy in the modeling framework and make several suggestions that more accurately reflect the prospects for advanced nuclear to cost-effectively contribute to the energy future of TVA. Our comment addresses two main issues:

- Scenarios involving economy-wide energy and carbon policy (primarily carbon taxes and Inflation Reduction Act tax credits) are not always consistent within and across scenarios, which may obscure how policies could limit or encourage advanced nuclear technology; and
- TVA's assumptions regarding the cost and commercial availability of advanced nuclear technology are unduly conservative.

We suggest changes to the Draft IRP analysis that would better characterize the role that advanced nuclear technology can play in TVA's resource plans under a range of realistic scenarios. While we believe that some of these alterations could improve the overall core analytics, we recognize that they could also form the basis for a robust sensitivity analysis.

Clean Energy and Carbon Policy in Scenarios

TVA appropriately differentiated scenarios by carbon policy conditions, along with load growth, energy prices and other factors. However, some of the important parameters that define carbon policy are not well supported and should, at a minimum, be explored through additional sensitivity analysis. The parameters that reflect the implementation of the Inflation Reduction Act tax credits for clean technology are very important and need to be consistently applied. The assumed 40% IRA investment tax credit level is reasonable for the TVA region's supply technologies. However, the IRA tax credits deviate from the

40% level in the Net-Zero Regulation Scenarios. Under the IRA, tax credits begin to phase out for new facilities that commence construction after 2032, or when power sector greenhouse gas emissions decline by 75% relative to 2022 levels, whichever is later. When that criterion is met, the tax credits would phase out over a three-year period: 75% of the initial value after the first year, 50% of the initial value after the second year, and 0% after the third year. In the Net-Zero Regulation scenario (attaining net-zero emissions by 2050), TVA predicts that the IRA emission reduction criteria would be met in 2034, triggering the three-year phase-out beginning in 2035. Given an assumed construction period of 8 years, a full ITC would not be available for nuclear units that entered service in 2043 or later. Relative to the availability dates of 2033 (Light Water SMR), 2038 (APWR) and 2041 (Gen IV SMR) there is a short window in which nuclear energy would qualify for the full ITC in this scenario.

An emission reduction of 75% over a 12-year period (2022 – 2034) likely requires significant regulatory pressure (such as the assumed high carbon tax) and would likely be accompanied by some favorable changes in clean technology costs arising from accelerated deployments, as is assumed in the Net-zero Regulation plus Growth scenario. In fact, the Net-zero Regulation plus Growth scenario assumes an ITC at the <u>50%</u> level through 2050 <u>and</u> reduced capital cost assumptions (along with a lower carbon tax than assumed in the Net-zero Regulation scenario). The 50% ITC through 2050 assumption appears to be a proxy for anticipated cost reductions arising through rapid deployment, and not a literal modification of the IRA statute. In the Net-zero Regulation plus Growth scenarios, TVA implements lower capital cost assumptions for most technologies by substituting lower NREL "Advanced" case parameters for the default "Moderate" case parameters. However, in the case of nuclear energy, TVA shifts from TVA's internally derived cost figures to the 2023 NREL "Moderate" case nuclear energy costs.

While NIA recognizes the role of growth in technological advancement, we question the realism of assuming no changes in technology costs combined with a phase-out of an important tax credit in one Net-Zero Regulation scenario (along with imposing a high carbon tax), while reducing technology costs and raising the effective tax-credit in another Net-Zero Regulation scenario that features a lower carbon tax (along with higher load growth). Both Net-Zero Regulation scenarios should assume lower capital costs arising from accelerated development and learning from early deployments.

We suggest that TVA explore the more recent 2024 NREL "Moderate" and "Advanced" cases as an alternative source of nuclear costs in both Net-Zero Regulation scenarios, and reconsider how the ITC provisions might change over time to reflect the continuing role of federal policy in attaining deep emission reductions.

Projected Cost and Availability of Advanced Nuclear Technologies are Too Conservative

Despite near-term challenges in construction cost and timeline, the advanced nuclear industry is poised to develop a thriving industry over the next decade. Terrapower, in partnership with the U.S. Department of Energy (DOE) expects their Natrium reactor to be operational "as early as 2030" and has started construction in Kemmerer, Wyoming. X-Energy expects to complete their Seadrift, Texas project, in partnership with Dow Chemical and DOE in the early 2030s. X-energy is also working with Amazon and Energy Northwest to support a 320 MW project in central Washington and aiming to complete 9 GW of projects by the end of the 2030s. Additionally, Kairos Power and the NRC have demonstrated licensing competency and timeliness with the efficient sequential licensing of the Hermes 1 and 2 reactors. Kairos Power has also signed a long-term project development agreement with Google.

Given these recent developments, TVA appears to be unduly conservative in both the timing of commercial availability and the trajectory of costs of advanced nuclear technologies. TVA bases the IRP nuclear costs on their experience in examining small modular reactors for Clinch River while adopting most other technology costs from the 2023 NREL Annual Technology Baseline (ATB) projections for future costs. While the TVA experience at Clinch River is certainly relevant in the near term, recent projections from reputable sources may be better over longer timescales.

Commercial Availability and Construction Times

The timing of new nuclear projects appears to be based on an assumed 8-year construction period (based on Figure 3-8) and incorporates single-unit build limits of one unit per year in the modeling. TVA estimates that the earliest available completion dates for a Light Water SMR, Advance Pressurized Water Reactor, and Gen IV SMR are 2033, 2038, and 2041, respectively.

An 8-year construction timeframe ignores the advantages of smaller, standardized units, particularly over time as developers learn from early experience. SMRs will have less sitework because of their design and the higher percentage of factory-produced components. The X-energy project in Texas, for example, plans to bring multiple reactors online in a given year. While the one-unit-per-year limit on building a large (APWR) unit is reasonable, it may not be appropriate for SMR projects.

The 2041 date for the completion of the first Gen IV SMR assumes construction beginning in 2033, which is too conservative given that several Gen IV reactors around the country are slated to be completed by the early 2030s. The Terrapower, X-Energy, and Kairos projects mentioned in the previous section are all expected to be 5- to 6-year projects. Even if these first of a kind projects take 50% longer than anticipated to construct (around 8-years), TVA would be able to take advantage of the learning and expect shorter construction timelines on later projects.

The assumption that Gen IV SMRs are available 8 years after light water SMRs should also be revisited. In the United States, there are currently more investment dollars, both public and private, flowing into Gen IV projects and these projects are further in development than light water SMR projects (see Terrapower, X-energy, Oklo, and Kairos relative to LWR counterparts like NuScale, Westinghouse AP-300, and GE BWRX-300). A scenario where the light water and Gen IV SMRs are allowed to come online at the same time in the early-to-mid 2030s would be one realistic scenario.

Finally, it appears that an 8-year construction time in the IRP applies to all nuclear units (again based on the data in Figure 3-8). If that is the case, construction time assumptions should be revisited given the fact that one of the advantages of small units is their shorter construction times, especially when built as multi-unit facilities. Also, as more units of either type are built, construction times will likely shorten at a quicker pace for SMRs than large LWRs. As a reference, the NREL ATB database assumes different construction periods for small and large units, which also vary by case. The 2024 ATB assumes that large unit projects will take 10, 7, and 5 years to complete in the “Conservative,” “Moderate,” and “Advanced” cases, respectively, and that small unit projects would take 6, 5 and 4 years in those cases.

Capital Cost Trajectory

Figure E-2 (reproduced below) shows long run capital costs rising in nominal terms, suggesting costs that remain roughly constant in real terms through 2050. This is extremely conservative, particularly when contrasted with 2024 ATB costs for small modular reactors. The initial Light Water SMR appears to be a First-of-a-Kind (FOAK) unit available in 2033, and in subsequent years falls in cost to reflect an Nth-of-a-Kind (NOAK) unit. It is not clear whether this represents a multi-unit site that initially builds a FOAK SMR and then a second NOAK unit, or if TVA can simply forego the FOAK stage and wait until NOAK units become available. Because of the rapidly evolving status of advanced nuclear energy, it is important to characterize nuclear opportunities and constraints accurately, beyond simple cost parameters. This means developing a clear narrative that may be more detailed than needed for other technologies in resource modeling.

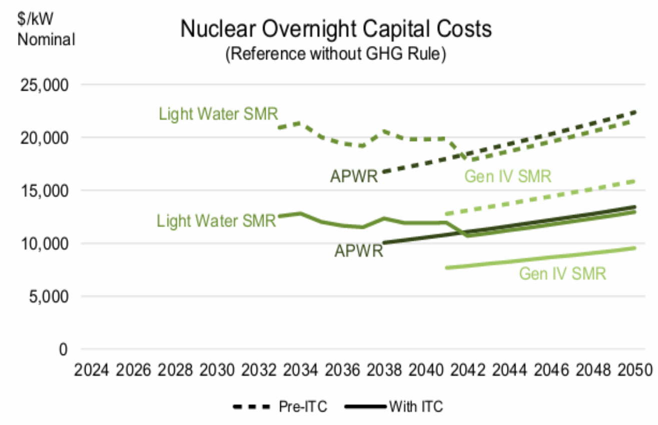
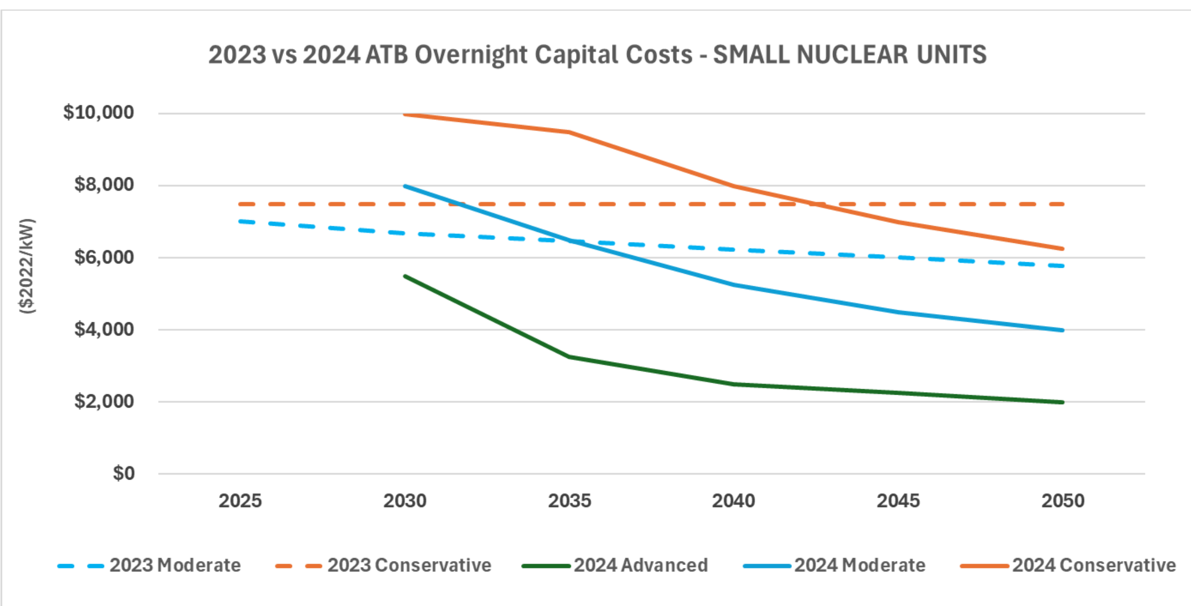
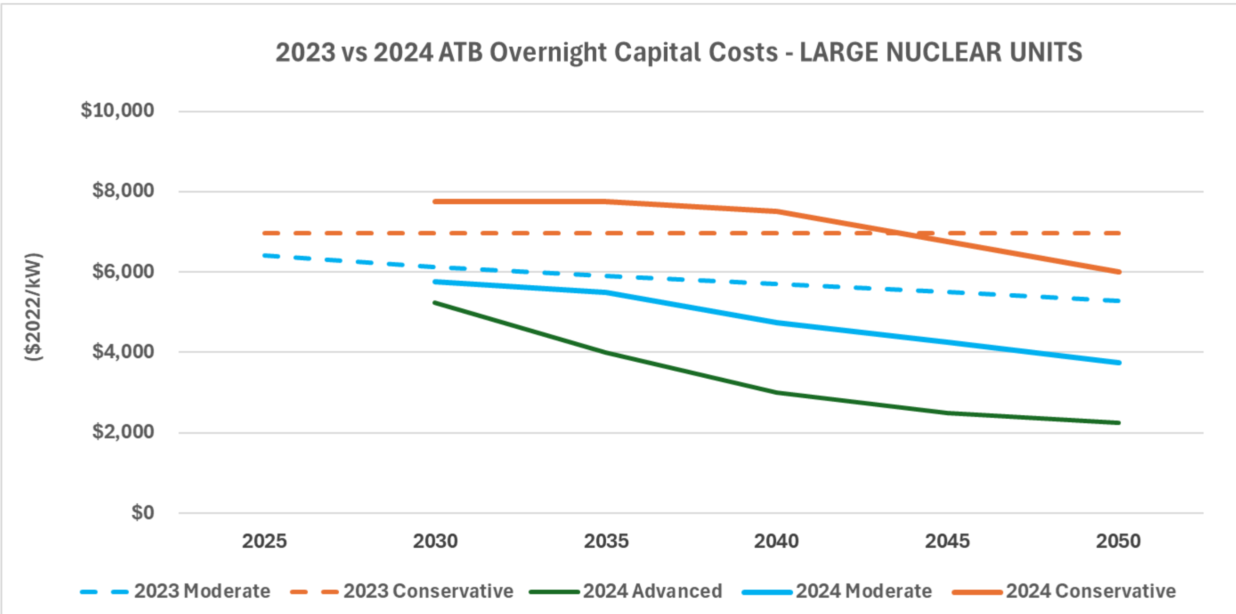


Figure E-2: Nuclear Overnight Capital Costs (Reference without GHG Rule scenario)

The graph below shows both the 2024 and 2023 NREL ATB capital costs for small reactors, expressed in real 2022 dollars (NREL added the "advanced" case to the nuclear ATB for the 2024 version). In contrast to the TVA assumptions, these cost projections assume that cost reductions (in real dollar terms) would occur over the study horizon, which is consistent with the advantages of replicating additional units over time and developers applying learning through early experience to later units.



The Advance Pressurized Water Reactor (APWR) in TVA modeling is a large (1,150 MW) unit which, while not identical to the ATB version (1,000 MW for "Advanced nuclear light water and non-light water technologies"), could still be instructive for projecting costs. The overnight capital costs for large units from the 2024 ATB in real terms are shown below:



Summary of Suggested Modifications to TVA Modeling and/or Additional Sensitivity Analyses

NIA believes that TVA should consider modifications of the core analyses to address the issues raised above, at least in some scenarios/strategy pairs. However, we recognize that substantial modifications may not be feasible at this stage. If that is the case, these issues should form the basis of a robust set of sensitivity analyses focused on the depiction of carbon policy, the opportunities and constraints of building multi-unit nuclear facilities, and the assumptions regarding construction time and capital costs.

In summary, we suggest TVA:

- Explore how the ITC provisions might change over time to reflect the continuing role of federal policy in attaining deep emission reductions;
- Consider utilizing the 2024 NREL ATB cost trajectories, in particular the "Moderate" and "Advanced" cases in the Net-zero Regulation scenarios, which depict ongoing cost reductions achieved through deployment and learning;
- Differentiate the construction time assumptions across nuclear technology types and between scenarios to reflect different assumed market conditions;
- Ease the constraint of one nuclear unit completed per year for SMR technology; and
- Assume earlier commercial availability of Gen IV SMR to reflect shorter construction periods from increased market activity.

NIA would like to thank TVA for the opportunity to comment on the 2025 Draft Integrated Resource Plan and would be happy to discuss our suggestions further. If you have any questions, please contact us at the email addresses listed below.

Sincerely,

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